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LOCATING CORROSION ON OPERATING TRANSMISSION LINES WITH AN INFRARED CAMERA
- A Feasibility Study -

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ABSTRACT

Experiments with a high resolution infrared camera were marginally successful in detecting localized zinc loss from the core wire of an operating ACSR conductor under ideal laboratory conditions. Tests with a corroded core wire were not attempted but indications are that small patches of severe corrosion or broken strands should be detectable with special effort. Uniform corrosion, no matter how severe, would not provide enough contrast between the hot and cold parts of the conductor to insure a positive indication of corrosion. As a means of locating and quantifying corrosion on ACSR conductors the method does not look practical with presently available technology.

1. INTRODUCTION

Ontario Hydro has a need to survey its older transmission lines in order to evaluate the condition of all ACSR conductors placed in service prior to 1950. A progressive loss of zinc from the steel core wires may lead to severe corrosion and a serious loss of strength. In the past year an electronic instrument (nicknamed the CORMON/1/) has been successfully used to survey old lines as part of the program of transmission line refurbishment. Its design purpose is to detect the loss of zinc on the central core wires; it cannot measure the amount of corrosion on the steel or aluminum nor can it detect broken strands. As a zinc detector the instrument works well, but it requires direct contact with the conductor in a labour-intensive process that permits only piecewise sampling along the line. An infrared camera, on the other hand, might make it practical to check the conductor from the ground or even, perhaps, from a moving vehicle or

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helicopter. The idea is not a new one /2/ and depends on the detection of nonuniform heating along the conductor due to corrosion on the core and other factors such as broken or corroded aluminum strands.

The galvanized steel core wires provide most of the tensile breaking strength† in ACSR conductors but only about 2.5% of the electrical conductivity. If conductor heating is incrementally greater in areas of zinc loss then it will likely take a very sensitive infrared camera to detect it. The concept would fail for situations where there was a uniform loss of zinc but any variability might show up as longitudinal dappling of the infrared image. Some credibility is given to these notions by two different Ontario Hydro maintenance workers who reported seeing anomalous conductor warm-spots during routine infrared field surveys of compression sleeves (joints). Outwardly these spots did not show evidence of birdcageing or broken strands and so they concluded that the heating was a result of internal corrosion.

In an effort to substantiate these observations, some simple laboratory experiments were done to test the feasibility of detecting zinc loss with the same model of infrared camera presently used in the field for the location of overheated joints.

2. HEAT-RUN TEST

To make the experiment convincing, a real but small diameter sample of ACSR (3/0 (6/1)) was set up in the laboratory under controlled conditions. A 14 metre length was energized from a current source and allowed to stabilize at approximately 50°C in a draft-free room. Corrosion was simulated over a 0.5 metre length by removing the zinc from the steel core wire with a dilute solution of sulphuric acid and copper sulphate. (The copper sulphate acts like a catalyst and speeds the etching of the zinc in preference to the aluminum.) An electronic scan of the etched portion with an eddy current sensor‡ confirmed that all the zinc had been removed. A resistance measurement♦ showed that the conductor resistance had increased by about 1%. This value is suspect, however, because it results from the difference between two numbers of similar magnitude. The zinc layer is so thin (0.09 mm) that its effect is difficult to measure in a situation where the conductor is highly conducting to begin with. A theoretical calculation predicts that the etching should increase the resistance by only 0.33%. The resistance change of real weathered conductor is probably greater than the zinc loss calculation would predict since the calculation does not include steel loss from pitting and corrosion. A situation involving aluminum corrosion was not considered in these experiments since this kind of problem is not common in Ontario and the CORMON is not capable of detecting it.

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† Note that the breaking strength differs from the normal tension forces which are shared almost equally between the steel and aluminum.

‡ This sensor is the CORMON instrument referred to in Reference 1.

♦ All resistance measurements were made with an A.B. Chance Digital Micro Ohmmeter.

3. LABORATORY IR MEASUREMENTS

Experiments to detect the half-metre patch of missing zinc with a sensitive infrared camera[§] were initially successful, but reliable observation required that the conductor temperature be greater than approximately 80°C. The warmest spot stood out best when the camera sensitivity was adjusted so that the cooler parts of the conductor just vanished below the threshold of perception as seen on the video monitor. This adjustment took some care and might be difficult under field conditions. (When searching for slight temperature differences it is not necessary or desirable to calibrate the camera for absolute temperature measurements.)

It was then proposed that the visible warm-spot might only be the result of a variation in emissivity resulting from a slight staining on the conductor in the region of the acid treatment. The staining was a thin copper coating that originated from the copper sulphate in the acid bath. To eliminate this concern the conductor was cleaned so that it was not possible to see any visible difference between the etched and unetched portions. The result was dramatic in that the cleaning almost eliminated any trace of the infrared image of the warm-spot. Raising the conductor temperature to 100°C produced a barely perceptible improvement. The faint image would probably be difficult to see under natural field conditions. It is likely that the two warm-spots observed in the field were exceptional and were caused by internal damage to the conductor that had a greater effect on the conductivity then that possible from a simple loss of zinc or a patch of corrosion. It is also possible that the observations were a result of surface deposits or localized corrosion that provided a contrast in emissivity. A variation in surface emissivity, for whatever reason, can fool the camera and give the illusion of varying temperatures and, therefore, a false indication of corrosion.

4. SUMMARY AND CONCLUSIONS

A high resolution infrared camera was used to test the idea that localized corrosion on ACSR conductors might result in a detectable warmer region. While limited success was obtained in locating a discrete area of missing zinc in the laboratory, the method is judged impractical for field work for the following reasons:

1) An infrared camera having 0.1 C° of resolution is barely able to detect the total loss of zinc coating under ideal laboratory conditions.

2) There is a chance that a severe, highly localized, patch of corrosion is detectable, but field experience has shown such isolated pockets are uncommon.

3) There is some confidence that broken aluminum strands can be detected but this was not investigated.

[§] The camera was a model #450 made by AGEMA. It has a temperature resolution of 0.1°C.

4) A uniform loss of zinc or homogeneous region of corrosion would not be detectable because the resulting uniform conductor temperature provides no discernible variation of the video image.

5) Random surface conditions, from pollution, can result in variability of surface emissivity and cause confusion with valid temperature changes from corrosion.

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